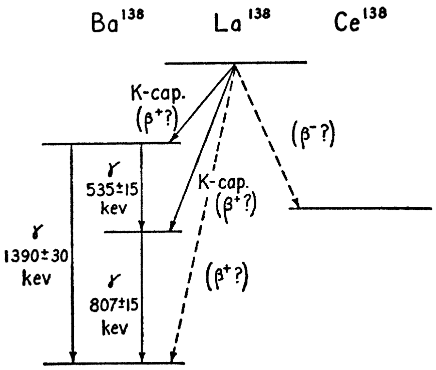

FIG. 3. Suggested disintegration scheme for La^{138} (half-life 2.0×10^{11} years).

ray spectrum end point. The distribution of Fig. 1 has been confirmed by photography of the spectrometer pulse height distribution displayed on the screen of a Tektronix 511A oscilloscope. Figure 2 corresponds to a 40 hour exposure at *f*:4.5 with fast ortho film. The top line in this spectrum is due to the 1390-kev gamma-ray, and below we have a broad band corresponding to the Compton distribution marked C in Fig. 1, and two sharper lines at 807 kev and 535 kev. A halo is observed on the film due to light coming from the oscilloscope filament.

Use was made of the known variation of instrumental detection sensitivity with gamma-ray energy to estimate the relative intensities of the gamma-rays at 1390 kev, 807 kev, and 535 kev as 1:0.65:0.3, respectively. If we recognize that, within the limits of error for the measurement of the gamma-ray energy, the 1390-kev gamma-ray appears to correspond to a crossover transition, we are then led to a decay scheme of the form given in Fig. 3, in which the gamma-rays have been associated with a *K* capture process to Ba^{138}. A search for electrons or positrons with a thin window Geiger counter indicated that the number of these particles with energy greater than 100 kev is less than 0.2/sec-g of ordinary lanthanum. On the basis of the proposed gamma-ray transitions of Fig. 3 and their estimated relative intensities, the activity of La^{138} has been estimated at approximately 0.45 disintegations/sec-g of ordinary lanthanum, corresponding to 0.6 gamma quanta/sec-g of all energies. In obtaining this latter figure a comparison of the observed gamma-activity was made to the gamma-activity of a known mass of potassium salt (giving rise to 3.3 gamma-quanta/sec-g.[2]

It remained to find evidence for the proposed decay scheme of Fig. 3 in the Ba x-rays which should accompany the *K* capture process. Figure 4 gives the result of a search for this radiation in which the height distribution of the scintillation spectrometer pulses was examined in the region of 30 kev. For calibration and comparison the 29-kev x-ray following the decay of I^{131} is also given in Fig. 4. We are led to the conclusion that an x-radiation of energy 32±1 kev is associated with the decay of La^{138}, a value which corresponds better to the Ba x-ray line at 31.4 kev than to the 33.7 kev x-ray line of Ce which might arise if La^{138} decayed by beta-emission to Ce^{138}. In order to estimate the number of x-rays emitted, a much smaller sample ($\frac{1}{3}$ g) was used, and a value of approximately 0.4 x-rays/sec-g of ordinary lanthanum was found, in good agreement with the number to be expected on the basis of the proposed decay scheme. We conclude that the half life of La^{138} is approximately 2.0×10^{11} years.

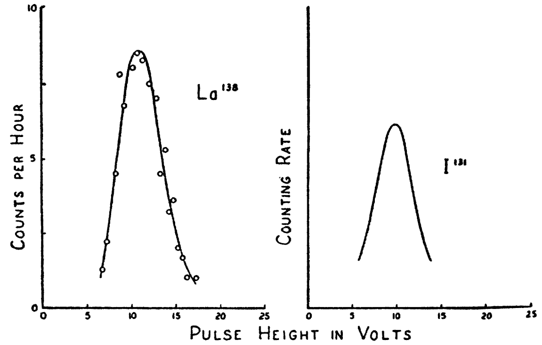

FIG. 4. Scintillation spectrometer pulse height distributions in the x-ray region, showing (left) the 32-kev radiation associated with the natural activity of lanthanum, and (right) the x-radiation associated with the decay of I^{131} for calibration.

Our thanks are due to the National Research Council of Canada for the support of this work.

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Coincidence Studies in the Decay of La^{140}*

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PREVIOUS work on the decay of La^{140} has been confined largely to energy determinations.[1-3] The coincidence experiments that have been reported were absorption measurements[4] performed with Geiger counters. Two different decay schemes have been proposed.[1,2] Therefore it might be of interest to investigate the decay of this isotope using the new techniques based on the proportional properties of scintillation detectors.[5]

A sample of La^{140} was obtained by neutron irradiation of lanthanum oxide in the Oak Ridge pile. Using a thick source (~0.1 g/cm^2) a beta-gamma coincidence experiment was performed. The beta-ray detector has been described elsewhere.[6] The gamma-rays were detected in a 3-cm cube of NaI(Tl). This experiment indicated that the 1.60-Mev gamma-ray is in coincidence with the most energetic beta-rays. Gamma-gamma coincidence experiments showed that the 1.60-Mev and 0.82-Mev gamma-rays are coincident.

The angular correlation[6-8] between these two gamma-rays was also investigated. Again the 1.60-Mev quantum was detected in a 3-cm cube of NaI(Tl). One discriminator was set to accept those pulses in the unresolved "Compton plus photoelectric" peak of the pulse-height spectrum. The 0.82-Mev quantum was detected in a cleaved piece of NaI(Tl) having dimensions $\frac{5}{8}$ in.×$\frac{5}{8}$ in.×$\frac{1}{8}$ in. The pulse-height spectrum from the thin crystal showed a strong photoelectric peak for the 0.82-Mev gamma. A second discriminator was set to accept this (0.82-Mev) photoelectric peak. The outputs of the discriminators were fed to a coincidence circuit. Parallel channels of fast amplifiers and a fast coincidence circuit served to reduce the accidental coincidence rate by requiring a fourfold coincidence. Some 2-3000 fourfold coincidences were counted at each of four angles. The results are shown in Table I.

We may begin to build a decay scheme by observing that the most energetic beta-ray branch of energy 2.26 Mev,[1] is followed by the 1.60-Mev gamma-ray; probably to the ground state of Ce^{140}. The softer beta-ray branches[1] must lead to the 1.60-Mev level through the emission of the 0.82-Mev gamma-ray, and to other levels of Ce^{140} through the emission of the other gamma-rays which have been observed.[1-3] We assume a partial decay scheme

TABLE I. Angular correlation of La^{140} gamma-rays.

	$W(90°)$	$W(120°)$	$W(150°)$	$W(180°)$
Experiment	1	1.016±0.027	1.146±0.031	1.147±0.033
Theory (see text for assumptions)	1	1.033	1.112	1.157

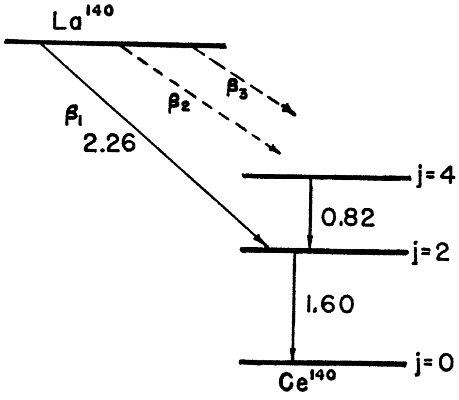

FIG. 1. Partial decay scheme of La^{140} with spins assigned on the basis of angular correlation experiments.

which is shown in Fig. 1. This scheme is similar to the decay schemes[8] of other odd-odd beta-emitters such as Co^{60}, Na^{24}, Cs^{134}, Sc^{46}, Y^{88}. On this assumption, the results of the angular correlation experiment may be used to assign spins to the 1.60-Mev and 2.42-Mev excited states of Ce^{140}. Table I shows the correlation function W to be expected with finite geometry for the assignment of spins 4, 2, 0 and quadrupole radiation.[7,8] This would be in accordance with the rule[9] for the spin of the first excited state of even-even nuclei.

There is some uncertainty[10] in the assignment of the 0.093-Mev gamma-ray in the decay scheme proposed by Beach *et al.*[1] If this gamma-ray does indeed occur between the 0.82- and 1.60-Mev gamma-rays, then the interpretation of the angular correlation experiment must be made on the basis of the triple correlation theory.[11] Further investigation of this isotope by means of precision coincidence spectrometry is necessary in order to determine the decay scheme unambiguously.

The authors are indebted to Professor George E. Owen of this university for helpful discussions of this problem.

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† AEC Predoctoral Fellow, 1950-1952.
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The Symmetry of Graphite

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THE writer has discussed the symmetry of graphite in an earlier communication.[1] At that time there was suggested a fundamental twofoldness of the c-axis. Evidence for this was presented in the form of a c-axis precession-type photograph of the zero-level of the reciprocal lattice. Because of the small size of the unit cell of graphite and the wavelength employed (Cu K_α), only the six reflections of the $10\bar{1}0$ group appeared on the film. Four of these were accompanied by satellite reflections which were symmetrically related among themselves by the operation of two perpendicular mirror planes rather than by rotation about the c-axis. The satellites were separated from the parent reflections by a distance one-fifteenth of the reciprocal a-axis.

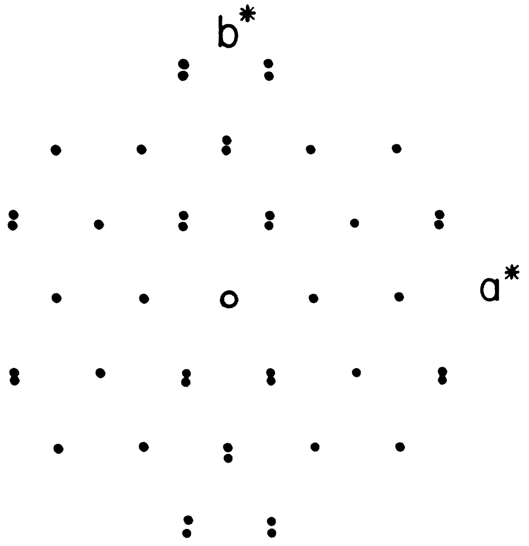

FIG. 1. Schematic representation of the c-axis, zero-level of the reciprocal lattice of graphite showing array of satellite reflections.

Since there were insufficient data to permit interpretation of the satellite reflections when copper radiation was used, experiments are being conducted with Mo K_α radiation monochromatized with rocksalt. Although these experiments are incomplete, it is believed that the accompanying illustration, Fig. 1, of the c-axis, zero-level of the reciprocal lattice, drawn schematically, is of considerable interest, since it extends and confirms the earlier results.

The inner ring of Fig. 1 represents that part of the reciprocal lattice illustrated in Fig. 3(b) of the earlier communication.[1] As mentioned before, the satellites are separated from their parent reflections by one-fifteenth of the reciprocal a-axis (conventional hexagonal graphite cell). This separation is maintained as one proceeds out the reciprocal a-axis of the orthorhombic supercell. The separation doubles and then triples in the direction of the reciprocal b-axis. The intensities of the satellites are of the order of one-fiftieth that of the parents.

Work on the n levels is continuing. Preliminary results indicate that satellites associated with reflections on the first level lie on the opposite side of the parent reflection from those on the zero-level.

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Polarization Effects in n-p Scattering*

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THE expected azimuthal asymmetry in a double scattering of high energy neutrons by protons has been calculated using the "half-exchange" n-p interaction of Christian and Hart.[1]

If the first incident beam and both targets are unpolarized, then the intensity of the twice-scattered neutrons is given by

$$J(\theta_1, \theta_2, \phi_2) = I_1(\theta_1)I_2(\theta_2) + Q_1(\theta_1)Q_2(\theta_2)\cos\phi_2.$$

$P_y(\theta_1, \phi_1=0) = [Q_1(\theta_1)/I_1(\theta_1)]$ is the component of polarization normal to the plane of the first scattering of the once scattered neutron beam. $Q_2\cos\phi_2$ is the I_P defined by Wolfenstein.[2]